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FOREIGN TECHNOLOGY DIVISION

SHORT RANGE ATTACKING GUIDED MISSILE

By

Lu Yao-liang

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Short Range Attacking Guided Missile

Lu Yao-liang

A short range attacking missile is an air-to-air missile of high maneuverability, which has been developed in the recent ten years to meet the need of interceptors in short range fightings. This article beginning with the development of air-to-air missiles tries to make a brief description of the origin, models and the property of short range attacking guided missiles.

After World War II, due to the prolonging of life span and the continuous improvement of self-defense weapon of bombers, it has become very difficult for an interceptor by using aircraft automatic cannon to destroy a bomber. In addition, when an interceptor uses aircraft automatic cannon to attack a bomber, it must occupy a position behind the bomber, which is good for attacking and which is within the effective range (200-1,000m) of the aircraft automatic cannon. But at such a distance, the interceptor can often be hit by the self-defense weapon from the bomber. For the purpose of strengthening the firepower of an interceptor and for satisfying the need in fighting with a bomber, a guided weapon which has great power and can proceed to attack at a longer distance (beyond the attacking range of the self-defense weapon from a bomber) is urgently expected to come out. Under such circumstances, the study of manufacturing the early (first generation) air-to-air guided missile began to be underway. Through a period of development for about ten yaers, till the middle 1950's, various types of air-to-air guided missiles, such as "Sparrow" I AIM-7A, "Falcon" AIM-4A,

4B and 4C, "Sidewindre" 1A AIM-9B of US; "Alkali" of USSR; "Fireflash" of Britain; and Matra R.510 of France were all successfully manufactured and equipped in interceptors for use. As these missiles were designed for attacking bombers, which at the time had lower speed than interceptors, one characteristics of tactical use of them was to take a position suitable for trailing attacking. So the air-to-air guided missiles of first generation are called trailing attacking missiles (Figure 1).

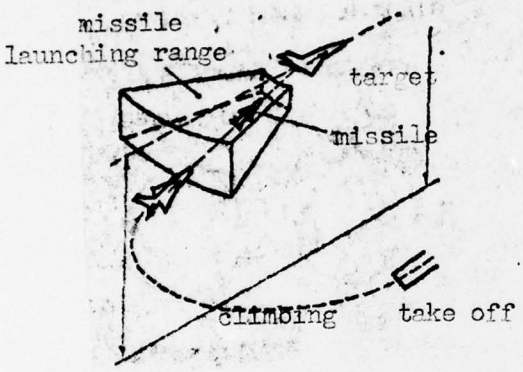

Figure 1 Diagram of interception made by an air-to-air missile of first generation

Later on, because of the manifest changes of the air destructive force, during the period from 1955 to 1960, the bombers propelled by piston engine of the post World War II era and later those propelled by turboprop were put out of service and replaced by medium range supersonic as well as subsonic long range bombers. And the traditional distinction between an interceptor and a bomber has also changed. Some countries in the West have manufactured tactical planes which can be used as both interceptor and tactical bomber. When it is necessary this kind of plane can carry out nuclear bombing. For satisfying these purposes, the velocity and climbing limit of bombers have aggravated, and the advantages (velocity, climbing and overload coefficiency) for an interceptor actively to take aim and to attack from the rare part are therefore

lessened, in other words, it has become more and more difficult for an interceptor take an advantageous position to attack a bomber at its rare part. An interceptor is therefore required to be able to make all-direction attack, namely attacking the target from any directions, tail, side and front (Figure 2). For making all-direction attack, an interceptor must be able to make an intercepting attack, like what American's "Sparrow"III AIM-7C, super "Falcon" AIM-F and 4G; Russian's "Awl" (AA-4); British Red Top" and French "Matra" R.530 can do.

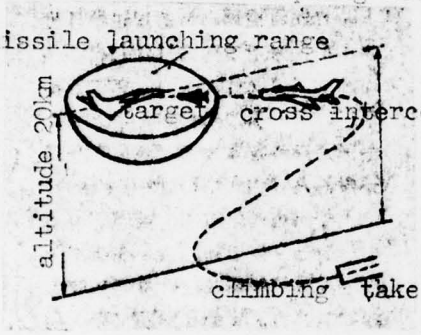

Figure 2 Diagram of interception made by an air-to-air missile of second generation

In the late 1960's, Some countries in the West began to develop air-to-air guided missiles of third generation. The new development includes the following features:

On the one hand, they continuously enlarge the attack range of the existing missiles and manufacture new long range missiles which can make upward and downward attack of all-altitude, such as American's "Falcon" AIM-47A, "Immortal Bird" AIM-54A; Russian's "Malicious" (AA-6); and French "Matra" R.530. The purpose of developing such all-altitude and long range air-to-air guided missiles is mainly to deal with the long distant invading target of high and low altitude (such as cruise missile).

On the other hand, they try to reduce the minimum launching distance,

to improve mobility, to enlarge attack range and to manufacture short range attacking missiles. The way in which the missiles of third generation attacking their target can be seen in Figure 3.

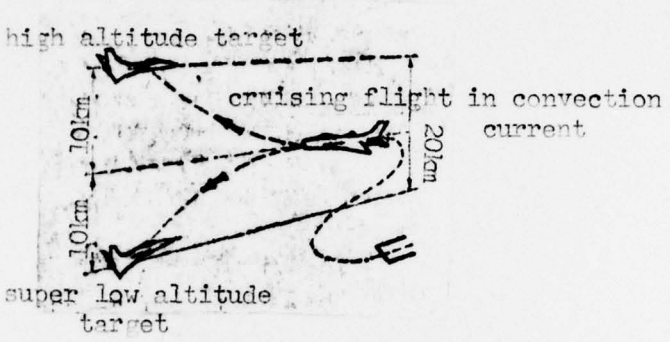

Figure 3 Diagram of interception made by an air-to-air missile of third generation

The Origin of Short Range Attacking Guided Missile

Ever since air-to-air gudied missile began to be equipped in and used by interceptors, and following the velocity increase of aircrafts, the enlargement of their attack range and the development of techniques of air-borne radar, and especially the advent of all-direction attacking missiles, of which the main target is the supersonic medium range bombers, some military experts in the West mistakingly believe that in air battles in the future, it will use long distant radar to discover targets and use air-to-air guided missiles to make interception. Their belief thereby means that the short range air battle by interceptors has beome something of the past. So there is no necessity to equipe with short range weapon--aircraft automatic cannon. Because some people blindly believe such misconcept and hold over confidence in air-to-air guided missiles, in the West , there came a tendency that "We need missiles not aircarft automatic weapon".

As a consequence, many interceptors are equipped with no more aircraft automatic weapon but missiles only. The Us interceptor F-4B, for example, is thus equipped. Some of the Russian interceptors, following the Western fashion, are equipped with only missiles, too. Many of the Western as well as the Russian military experts and leaders are those who believe in the theory of all-importance of weapon and they exaggerate the power of weapon to try to intimidate peoples in the orld and to intimidate themselves as well. Their incorrect conclusion leads to an overestimation of air-to-air guided missiles. But, during the 1960's, from the experience in Vietnam and the third Middle East war between Isreal and the Arabic nations, it has proved that in achieving air supremacy, the short range air battle is not out of date. The Us interceptor F-4B, for example, can carry eight air-to-air guided missiles, but it is not very successful to use these missiles to attack enemy interceptors in short range air battles. This is because that it takes a certain amount of time to locate target, to prepare for launching and to control the missile. When ~~everything~~ everything is ready, the chance of making attack may have been lost because the enemy has moved to a new position. Moreover, even the missiles are launched, the enemy plane can actively make maneuvering flight (circling with large ~~space~~ slope) to shun the missile. According to an article published in one journal in the United States, in the Vietnam war, the hit rate of the US air-to-air missiles (such as "Sidewinder"IA AIM-9B, "Sparrow"lll AIM-7D and "Falcon" AIM-4D) was 10%. And the Vietnamese people's air force collaborated with ground radar and using their aircarft automatic weapon really gave those Americans who"want missiles not automatic weapon" a good lesson.

Knowing that one characteristics of air battle among interceptors is short range fighting and that air-to-air guided missiles only cannot achieve air supremacy, since the late 1960's, the US air force began to study the problems concerning guided missiles in short range air battles. On the one hand, they began to reshape and to improve such air-to-air guided missiles as "Sparrow" and "Sidewinder" , as shortening their minimum launching distance and increasing their mobility so as to make them able to be used in short range air battles in Vietnam. Those transformed air-to-air guided missiles,which have had the ability to engage in short range fighting, are known as transitional short range attacking guided missiles, such as "Sidewinder" AIM-9G and 9H of US Navy, and "Sparrow"lll B AIM-7E-2 and 7F of US Air Force. On the other hand, in order to compete with Russia for supremacy, in 1968, the United States began to manufacture completely new short range attacking guided missiles. They are of two different types: One is "Agile" of US Navy and the other is AIM-82A of US Air Force. In addition, in 1969, again it was decided to use super "Sidewinder" AIM-9l guided missile (see Figure 4) before "Agile" being put into service. Now the super "Sidewinder" has been equipped in aircarfts of different types.

Figure 4 Guided missile super "Sidewinder" AIM-9L hanging underneath the wing of a plane

In 1967, France began to manufacture Matra R.550 "Magie" short rang attacking guided missile (Figure 5). It has now been put into service.

In 1968, England began to develop a short range attacking guided missile. At the time,

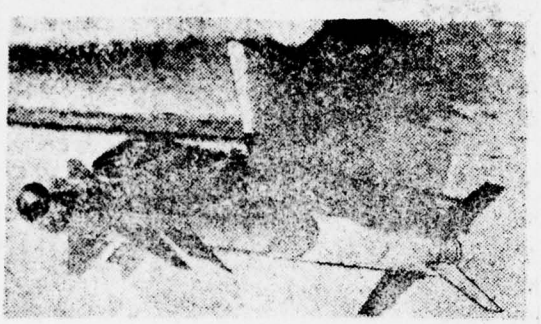

Figure 5 Matra R.550 guided missile hanging underneath the wing of a plane

- they decided to manufacture one missile called "Chasing Dog", and later they changed to develop a guided missile SRAAM. But for several reasons, the missile has not yet been manufactured.

Besides, in 1972, West Germany and Norway began to manufacture a kind of air-to-air guided missile named "Venomous Snake", which can be used both in medium range interception and in short range fighting. In the middle 1970's, Sweden developed an air-to-air guided missile Saab372, which can meet the requirements for medium range interception and short range fighting.

According to the report in a foreign journal, U.S.S.R. has developed a short range air-to-air guided missile AA-8. It is named by NATO as "Aphid".

Different Types of Short Range Attacking Missiles

Air battle among interceptors is different from that between bombers and interceptors, because interceptors of both sides all have great mobility. So if there is not much difference in property of the interceptors, on the one hand, one side will try to avoid the attack from the other, and on the other hand, one side will try to obtain an advantageous position to attack the other. Thus a short range fighting will be developed. In order to avoid the attack of an air-to-air guided missile from opposite side, an interceptor must make full use of its circling ability to circle inside the track of the missile. Because the velocity of the air-to-air missile is

very high, even the missile can produce larger overload than an interceptor, the rdius of its turn is still very large. If the plane makes a rapid turn (maneuvering flight), it will be able to avoid the attack by the missile. For example, a missile of M = 2 tries to attack an interceptor M = 0.8, of which the circling overload ≒ 4. If the missile want to hit the target and not be avoided by the target (follwoing the same radius to circle), the normal direction overload (aggregate of lift and thrust of the missile and specific value of its weight) produced by the missile must be 25 (see Figure 6).

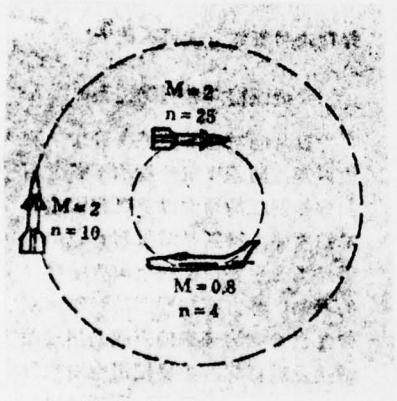

Figure 6

Even the circling angle speed is the same, the missile still have to have 10 overload. So, unless the missile can produce very large normal direction overload, the interceptor will be easily to circle following the inside track and to avoid the attack by the missile.

One of the causes that make an air-to-air guided missile fail in a short range air battle is that the mobility of the missile is not good enough to make quick turn. In other words, in attacking an interceptor, which always has great mobility, the missile often cannot have enough normal direction overload. So in the study of making new short range attacking missiles, this problem must first of all be solved. There are two ways to promote the normal direction overload: One is to increase the lifting power of the missile, and the other is to increase its thrust and the shaft angle of its bank axis. This means to use a thrust vector control structure.

The lift power can be improved either by choosing a new aerodynamic arrangement or by changing the shape of the rudder. For instance, it can use a double Duck model rudder or a double-delta Duck model rudder. The missiles , of which the outside aerodynamic setting is changed so as to obtain larger normal direction overload, are called short range guided missiles of aerodynamic control.

Missiles, by using thrust vector control structure to change thrust direction so as to promote the normal direction overload, are called short range guided missiles of thrust vector control.

Evidently, guided missiles according to their control forms can be classified into two different types: One is the aerodynamic control short range attacking guided missile (also called winged short range attacking guided missile), such as US super "Sidewinder" AIM-9L, USSR "Aphid" (AA-8). The other is thrust vector control short range attacking guided missile (also called wingless short range attacking guided missile), such as US "Agile" and British SRAAM.

The Property of Short Range Attacking Guided Missiles

As it is a fact that the target which a short range attacking guided missile intends to deal with is an interceptor which always has great mobility, so in manufacturing missiles, these measures must be considered very important, such as to reduce the minimun launching distance; to improve the mobility; to enlarge the attack range toward a target which is of high maneuverability; to shorten the responding time; to increase the hit rate; and to minimize the size and weight of the missile. A guided missile must have high degree of independence, thus it can minimize the limit of a

carrying plane and the missile will be more secure and more reliable and also it becomes simple to use as well as to maintain it. For satisfying these requirements, it has begun to use new techniques in manufacturing new guided missiles. Compared with the former ones, in aerodynamic setting, guiding system , control system and tactical use, the new missiles show all their characteristics respectively in these aspects:

1. Aerodynamic Setting

A short range attacking guided missile of aerodynamic control type usually has s Duck model aerodynamic arrangement . But for the purpose of promoting the lift power of a rudder, the Duck model rudder begins to have a new type of structure and shape, such as the French Matra R.550 "Magie" has a double Duck structure (Figure 7, 1). The Duck model rudder is composed of two sections: the front section is fixed and the rare section is movable. Using the gap effect of such an arrangement, the rudder can produce greater control lifting power to gain a lagre normal direction overload (more than 35). Thus the missile can have greater mobility in flight. The US super "Sidewinder" AIM-9L and the "Venomous Snake" of West Germany use double delta Duck model rudder (Figure, 2 and 3). A rudder of this shape is to make use of the edge wing, namely to use edge effect to increase lifting power and to reduce resistance.

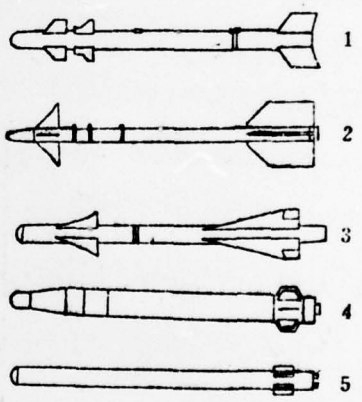

Figure 7 The appearance of a few short range attacking guided missiles. 1. double Duck model rudder, 2. and 3. Duck model double delta rudder, 4. and 5. wingless and folding tial wing.

The aerodynamic setting of a short range attacking guided missile of thrust vector control type is simply a bomb. For having stability of the missile in flight, at the rare part of the bomb, there is a folding tail wing ("Agile" has eight pieces, SRAAM has six), and the folding tail wing will automatically open after the missile has left the launching tube (Figure 7, 4and 5).

2. Guiding System

Most of the short range attacking guided missiles,at the present time, use infrared control system, and one of its characteristics is that it has a high degree of activeness and interference resistance. The homing head has a wider vision range and tracking angle.

The Us super "Sidewinder" AIM-9L, for example, for increasing activeness of its homing head, a cooling agent of original indium antimonide is used. The cooling method is by using an air bottle carried on the bomb to cool it. The homing head of "Agile" and super "Sidewinder" AIM-9L uses a double-filter interference resistance device. But the sensitive device will not receive any background radiation such as clouds. Based on the principle of double-filter, this technique is using the difference of radiation from the background and the target to filter out the useless signals. In addition, the homing head of both "Agile" and super "Sidewinder" AIM-9L has great tracking capability and can make over-shoulder attack (Figure 8). The attack range of "Agile" is larger than + and - 120°, and the super "Sidewinder" AIM-9L can make all-direction attack. Matra.R 550 "Magic" has high degree of activeness, and its homing head can sense $3\sim5\mu$

infrared radiation. Such a wave length is not only sensitive to the infrared rays radiated from the jet engine of a target, and also sensitive to the infrared rays radiated from the wasted gas, carbon dioxide, expelled from the engine. The attack range of the missile is thereby expanded. Besides, Matra R.550 "Magie" can be launched even under the condition of facing the sun, raining or snowing.

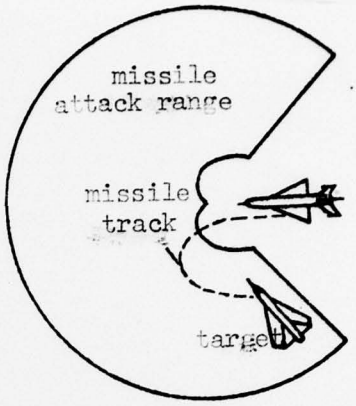

Figure 8 Diagram of over-shoulder attack

3. Control System

There are two different kinds of control systems of short range attacking guided missiles. One is aerodynamic control and the other is thrust vector control.

An aerodynamic control system is to use a controllable rudder to change flight direction of a missile. For being able to make quick turn, a missile is required to have greater lifting power. So as the aerodynamic setting and arrangement of an aerodynamic control type is concerned, a short range guided missile usually has a Duck model aerodynamic arrangement. This is because, compared with other types, a Duck model missile, under the condition of same lift area, can produce larger lifting power. Based on such a feature, in order further to improve the lifting power of the Duck model rudder, a double Duck model or a double delta Duck model rudder is generally adopted. The

main feature of the control system applied to a short range guided missile of aerodynamic control is to improve the Duck model aerodynamic control by chnaging it into a double Duck model aerodynamic control(such as Matra R.550 "Magie") or a double delta Duck model rudder aerodynamic control (such as super "Sidewinder AIM-9L and "Venomous Snake").

A thrust vector control is to make the thrust of a rocket engine produce eccentricity, and the eccentricity can be used to produce a controllable normal direction moment. By this moment the flight direction of a missile can be changed quickly. Obviously, this is an important way to enable a missile make quick turn. Among the known short range guided missiles, only "Agile", which has been abandoned, and the British SRAAM use thrust vector control. But the thrust vector control forms used by these two missiles are different. On the "Agile" it is through the revolving of the tail nozzle on the direction supporting stand to control direction. This thrust vector control structure,of which the largest turn angle is 20°, has succeeded in making "Agile" turn 15° in 0.3 second. And SRAAM uses the revolving of the four combustion air modulation blades set on the tail nozzle of the rocket engine to change the thrust direction.

4. Tactical Application

One of the features of the tactical application of short range guided missiles is that the launching distance is short. The shortest one is only several hundred meters. The shortest launching distance of "Agile", for example, is only 300 meters; Matra R.550 "Magie" is 500 meters and SRAAM is only 200 meters. The second feature is that the degree of depending

on the carrying plane is small, and the missile can be independent. For example, Matra R.550 "Magie" can be launched from interceptor "Illusion" F-1, which can make turn when the normal direction overload is larger than 6, and it requires no low speed limit from the carrying plane either. The third feature is that it can use human naked eyes to take aim.

In addition, Matra R.550 "Magie", "Venomous Snake", Saab372 and USSR "Aphid" all have wide attack range. Of Matra R.550 "Magie" the largest attack range is 6.5 kilometers in intermediate altitude and more than 10 km in high altitude. Of "Aphid" the largest attack range is 7 km. So these missiles, in addition to being used in short range fighting, can both be used in intermediate range fighting.

In addition to all those characteristics mentioned above, a short range guided missile is always of small size and light weight. For instance, the length of a bomb is usually less than 3 meters and the diameter is no more than 20 mm., and the weight is lighter than 100kg. All these characteristics are good for a light interceptor to carry and to use.

(Drawings by Tsu Shao-hsien)

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